



First Look at VIIRS Ocean Color Products

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The VIIRS (Visible Infrared Imager Radiometer Suite) sensor was successfully launched in November 2011. The VIIRS Ocean PEATE (Product Evaluation and Test Element) is tasked to evaluate the IDPS (Interface Data Processing Segment) ocean color data products from the VIIRS instrument [1]. Figure 1 shows a VIIRS product produced with NASA algorithms.

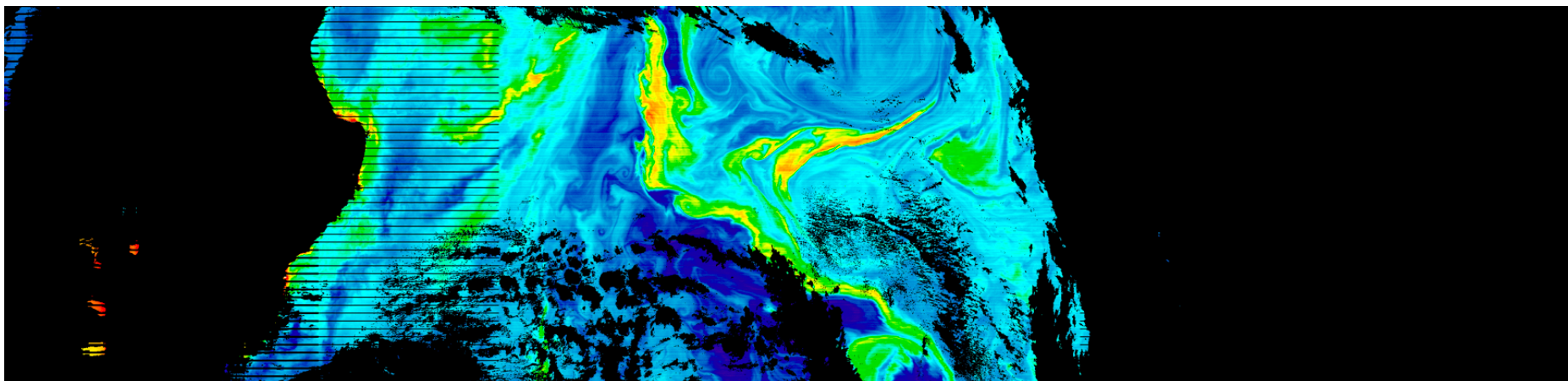
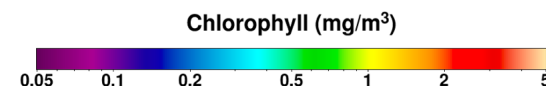


Figure 1: NASA-generated Level-2 Chlorophyll a product [2]



The image clearly shows oceanic structures (such as eddies and fronts) that are typical for ocean scenes. Furthermore, the impact of instrument artifacts such as instrument noise or stray light appears to be small.

The equivalent image derived from the IDPS VIIRS data products contain flags that eliminate such a large part of the data that a direct comparison is inappropriate. The VIIRS Ocean PEATE is currently working on deriving a methodology to compare the IDPS and NASA products.

A preliminary conclusion is that while the IDPS products appear to have some “issues”, the VIIRS instrument itself appears to be performing well and seems to be capable of producing realistic chlorophyll-a retrievals.



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References:

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NASA-generated Level-2 Chlorophyll-a product from file V2011325174257.L2_NPPS_OC from <http://oceancolor.gsfc.nasa.gov>

Data Sources: VIIRS NPP.

Technical Description of Image: The data was processed using the the calibrated top-of-atmosphere radiances as provided by the IDPS, using NASA's ocean color algorithms. An initial analysis suggests that the calibration of the top-of-atmosphere radiances need significant adjustments in several bands, therefore, the absolute level of the chlorophyll-a values will be uncertain. However, the relative structure seen in the chlorophyll-a data suggests that the VIIRS sensor is capable of producing realistic chlorophyll-a retrievals.

Figure 1: Chlorophyll-a product off the east coast of South America, produced with NASA ocean color algorithms.

Scientific significance: The data from VIIRS on NPP are needed to continue the climate data record of ocean color products (such as chlorophyll-a), started by SeaWiFS and MODIS on Aqua. The evaluation by the NASA Ocean PEATE will show whether the official data products are sufficient, or if improvements (e.g. regarding to the algorithms or the calibration) are required.

Relevance for future science and relationship to Decadal Survey: Currently, NASA relies on the data from MODIS on the Aqua platform to produce ocean color climate data records. The MODIS sensor is well beyond its design lifetime and the data quality is degrading, mainly due to an increase in the calibration uncertainty (scan angle dependent degradation of the reflectance of the primary scan mirror). NASA plans to continue the ocean color climate data records with the PACE and ACE missions, which are expected to launch in 2019 or later. VIIRS data is needed to bridge the climate data records of SeaWiFS and MODIS Aqua to those of the PACE and ACE missions.



Leveraging SMAP, Aquarius, & SMOS into a Long-Term Global Data Record by using East Antarctica as a Calibration Target

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Two missions with L-band passive microwave sensors have been recently launched: ESA's Soil Moisture and Ocean Salinity (SMOS) and NASA's Aquarius. A suitably homogeneous and stable external target may be able to serve as a transfer standard among SMOS, Aquarius, and future L-band radiometers such as NASA's Soil Moisture Active Passive (SMAP), enabling a longer-term observational record even if the missions do not overlap in time.

A recent study evaluated areas of East Antarctica (West Antarctica is too small & too variable) and found sub-kelvin stability over months for large regions. This is highly promising for all three missions.

Separating the geophysical changes (or lack thereof) from the instrumental changes, and quantifying the scaling-related uncertainties both can only be done with direct observations with in situ and airborne radiometry.

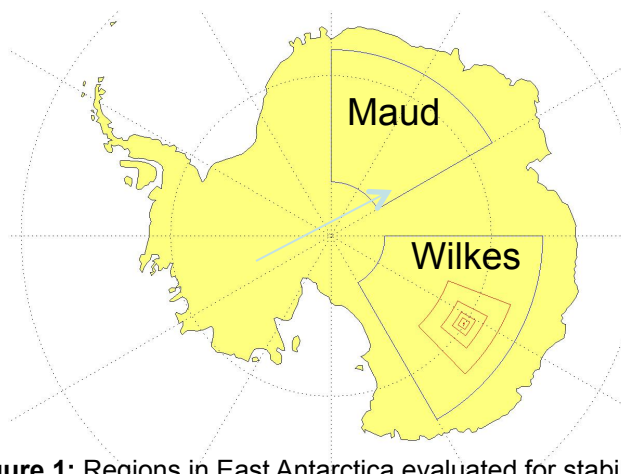


Figure 1: Regions in East Antarctica evaluated for stability. Nested boxes used to determine tradeoff between the number of observations (and therefore time required) vs. size of observation area for the region around Dome-C required to provide a given stability of the signal. Dome-C Nested Boxes 100km, 200km, 400km, 800km.

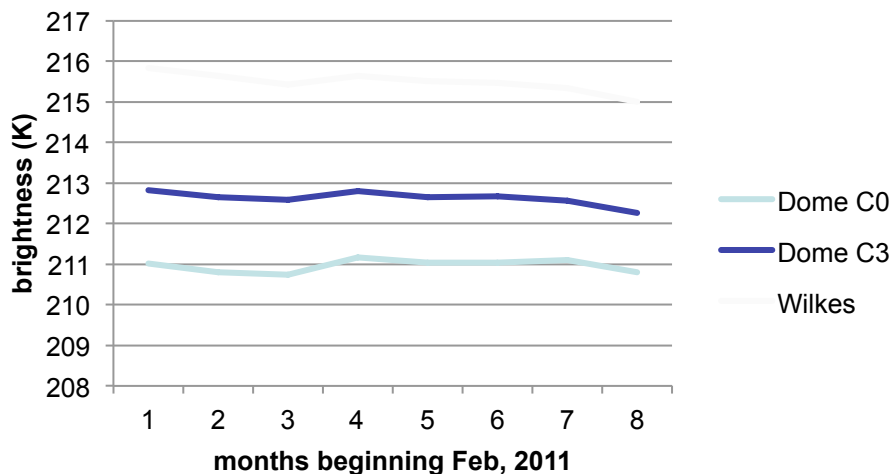


Figure 2: monthly averages beginning Feb, 2011 for 3 different size regions demonstrating excellent sub-kelvin stability. Maud result is similar to Wilkes.



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References:

Kim, E., "An Evaluation of Antarctica as a Brightness Temperature Calibration Target for SMOS and other L-band Missions", IEEE TGRS, in review, 2011.

Data Sources: European Space Agency gridded brightness temperatures (Level 1C) from the Soil Moisture Ocean Salinity (SMOS) mission were processed using a combination of custom and ESA-provided programs. Kim is a SMOS Validation Team PI & receives L1C data from ESA. The analysis is performed at GSFC, now using the NCCS supercomputer in order to handle the large data volume.

Technical Description of Image:

Figure 1: Observations regions investigated for suitability as calibration targets for L-band radiometer missions. Large regions provide immunity to localized jumps that have been observed at scales up to about 100-200 km. Large regions may also enable azimuth scan bias correction. Means, standard deviations, and histogram characteristics (not shown) were analyzed. Wilkes and Queen Maud regions were found to be statistically similar, so only Wilkes results are shown. In addition, statistics were computed for 100, 200, 400, and 800 km nested boxes centered on Dome-C to investigate spatial homogeneity in each area and to determine tradeoff between the number of observations (and therefore time required) vs. size of observation area for the region around Dome-C required to provide a given stability of the signal over the study period.

Figure 2: Monthly averaged daily mean brightness temperature (V-pol) for 3 different size regions: 100x100 km ('DomeC0'), 400x400 km ('DomeC3'), and the large Wilkes box. Note the sub-Kelvin temporal stability indicating that large regions such as these in East Antarctica are very stable over long time periods & therefore well suited for calibration of L-band radiometer missions.

Scientific significance: A new approach is evaluated to use passive microwave observations of Antarctica as a calibration target for L-band missions. The approach first identifies large-area spatio-temporal averages of brightness temperature that are stable enough to be suitable for use as calibration references. Second, filtering is shown to further improve the spatial homogeneity of the signal. **Two key uncertainties remain:** separating the geophysical changes (or lack thereof) from the instrumental changes. And, quantifying the scaling-related uncertainty between highly-stable ground measurements at a point vs. the 40km footprint-scale spatial patterns seen by SMOS (or SMAP in the future). These can only be determined by measurement. The former requires long-term monitoring by a radiometer in Antarctica. The latter requires measurement of the sub-footprint scale spatial variability, and this can only be done with an airborne microwave radiometer. **These needs were discussed at the last ESA-NASA bilateral meeting, and requires activities to begin at least two years prior to the field activities, due to the advance preparations needed for Antarctic deployment.**

Relevance for future science and relationship to Decadal Survey: Two L-band passive microwave missions have launched recently: ESA's Soil Moisture Ocean Salinity (SMOS, 2009) and NASA's Aquarius (2011). By 2015, a third mission, NASA's Soil Moisture Active Passive (SMAP, 1st-tier Decadal Survey), will launch. If data from these three missions is properly cross-calibrated, we could construct a global data record for soil moisture that spans a decade (longer if additional L-band missions are launched)---something that none of the individual missions is capable of alone. Such a long-term soil moisture dataset would be a huge advance for global hydrological modeling, numerical weather prediction, and climate studies.



Effective Tree Scattering and Opacity at L-band

Mehmet Kurum (UMD/ESSIC), Peggy O' Neill, Code 617, NASA GSFC

- For routine SM retrievals over terrain with light to moderate vegetation cover, the SMAP and SMOS baseline algorithms use the tau-omega model, a zero-order Radiative Transfer solution.
- This study (1) assesses the applicability of the tau-omega model for tree canopies, (2) determines effective values for tau (opacity) and omega (single-scattering albedo) for conifer trees, and (3) finally relates the effective parameters to their theoretical definitions.
- An explicit expression is driven for an effective albedo of vegetated terrain from the zero- and multiple- order RT model comparison. The results show that the definition of the retrieved effective albedo differs from that of the single-scattering albedo.
- While the single-scattering albedo represents single-scattering properties of vegetation elements only and is independent of ground properties, the effective albedo takes into account all of the processes occurring within the canopy, including multiple-scattering and canopy ground interactions.



Figure 1: ComRAD microwave instrument system deployed over stands of Virginia pine forest.

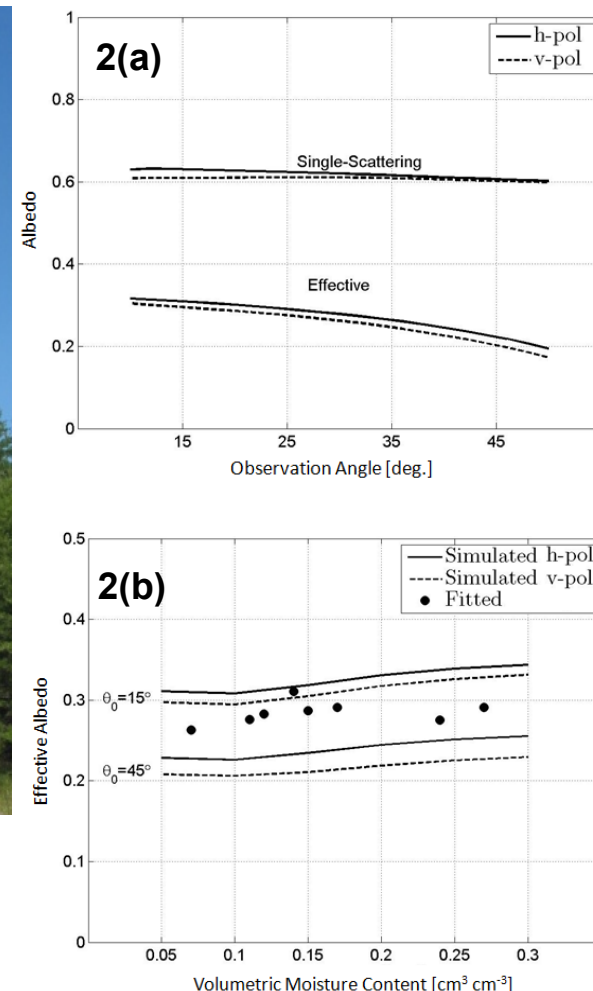


Figure 2: (a) The single-scattering albedo and “simulated” effective albedo of Virginia pine trees are plotted as a function of incidence angle.

(b) The “simulated” and “fitted” effective albedos of Virginia pine trees are plotted as a function of ground volumetric moisture.



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Kurum M., Lang R. H., O' Neill P. E., Joseph A. T., Jackson T. J., & Cosh M. (2011). A First-order radiative transfer model for microwave radiometry of forest canopies at L-band. *IEEE Transaction on Geoscience and Remote Sensing*, 49 (9), 3167– 3179.

Kurum M., O' Neill P. E., Lang R. H., Cosh M., Joseph A. T., & Jackson T. J. (in press). Impact of conifer forest litter on microwave emission at L-band. *IEEE Transaction on Geoscience and Remote Sensing*, doi: 10.1109/TGRS.2011.2166272

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Data Source: NASA's Terrestrial Hydrology Program has funded a three-year field experiment to measure the L band microwave response to soil moisture under different types of small to medium tree canopies. The project was a collaboration between GSFC, the George Washington University, and USDA. The truck-mounted ComRAD radar/radiometer instrument system was used to obtain microwave data over coniferous trees coincident with measurements of soil and vegetation properties (Kurum et al., in press).

Technical Description of Image: **Fig. 2(a)** shows results from both the theoretical single-scattering albedo and the simulated effective albedo for the conifer forest as a function of incidence angle for both polarizations (Kurum et al., accepted for publication). As seen from the plot, the single-scattering albedo is around 0.6 for both polarizations and depends weakly on angle of incidence and polarization because of the combined effect of vertical trunks and horizontal orientation of the primary branches. The simulated effective albedo values are in the range of 0.2 – 0.3, which are less than half of the theoretical single-scattering albedo but are also higher than the SMOS default effective albedo value of 0.1 for forest canopies. This reduced albedo becomes a global parameter for the whole canopy including the near-surface ground, and accounts for multiple-scattering effects by balancing the scattering darkening effects of single-scattering albedo with the multiple-scattering contribution. The plot also indicates that effective albedo values decrease monotonically with increasing angle. This is due to the increase in the contribution of multiple-scattering with increasing angle (Kurum et al., 2011). **Fig. 2(b)** shows the effect of ground moisture on the simulated and fitted effective albedo. In this plot, the effective albedo values are obtained from measured data as a best-fit parameter that minimizes the difference between measured data (see **Fig. 1** for the measurement setup) and the zero-order radiative transfer (RT) model results for all available incidence angles. The simulated albedos are calculated at incidence angles of 15° and 45°. In the calculation of the best-fit effective albedo, vegetation parameters are taken to be independent of polarization and angle while horizontal (solid lines) and vertical (dashed lines) polarizations are considered in calculation of simulated effective albedos. The results represent the albedo values over a wide range of ground conditions, where ground moisture varied between 0.05 – 0.30 cm³ cm⁻³. The simulation results indicate a slight increase in the effective albedo with an increase in ground moisture content. On the other hand, the zero-order RT model-fitted effective values seem to be independent of the moisture content of the ground but have a magnitude similar to the simulated ones.

Scientific Significance: For routine microwave soil moisture (SM) retrieval through vegetation, the tau-omega model [zero-order radiative transfer solution] is attractive due to its simplicity and ease of inversion and implementation. It is the model used in baseline retrieval algorithms for several planned microwave space missions, such as ESA's Soil Moisture Ocean Salinity (SMOS) mission (launched November 2009) and NASA's Soil Moisture Active Passive (SMAP) mission (to be launched late in 2014). These approaches are adapted for vegetated landscapes with effective vegetation parameters tau and omega by fitting experimental data or simulation outputs of a multiple scattering model. The model has been validated over grasslands, agricultural crops, and generally light to moderate vegetation. Knowledge of vegetation features at L-band appears to be of great importance for either correcting for the vegetation effects on SM retrievals or determining vegetation wet biomass itself. This study is concerned with effective vegetation parameterization of the tau-omega model when applied over trees.

Relevance for future science and relationship to Decadal Survey: Effective characterization of a forest canopy should help scientists to extend accurate soil moisture retrievals from global space mission to more areas of the Earth's surface than are currently feasible. This project provides quantitative assessments of vegetation scattering and attenuation, eventually leading to improved SM retrievals and vegetation characterization for moderately to densely vegetated areas from microwave missions in space.